

WorldCom CyberSeminar:

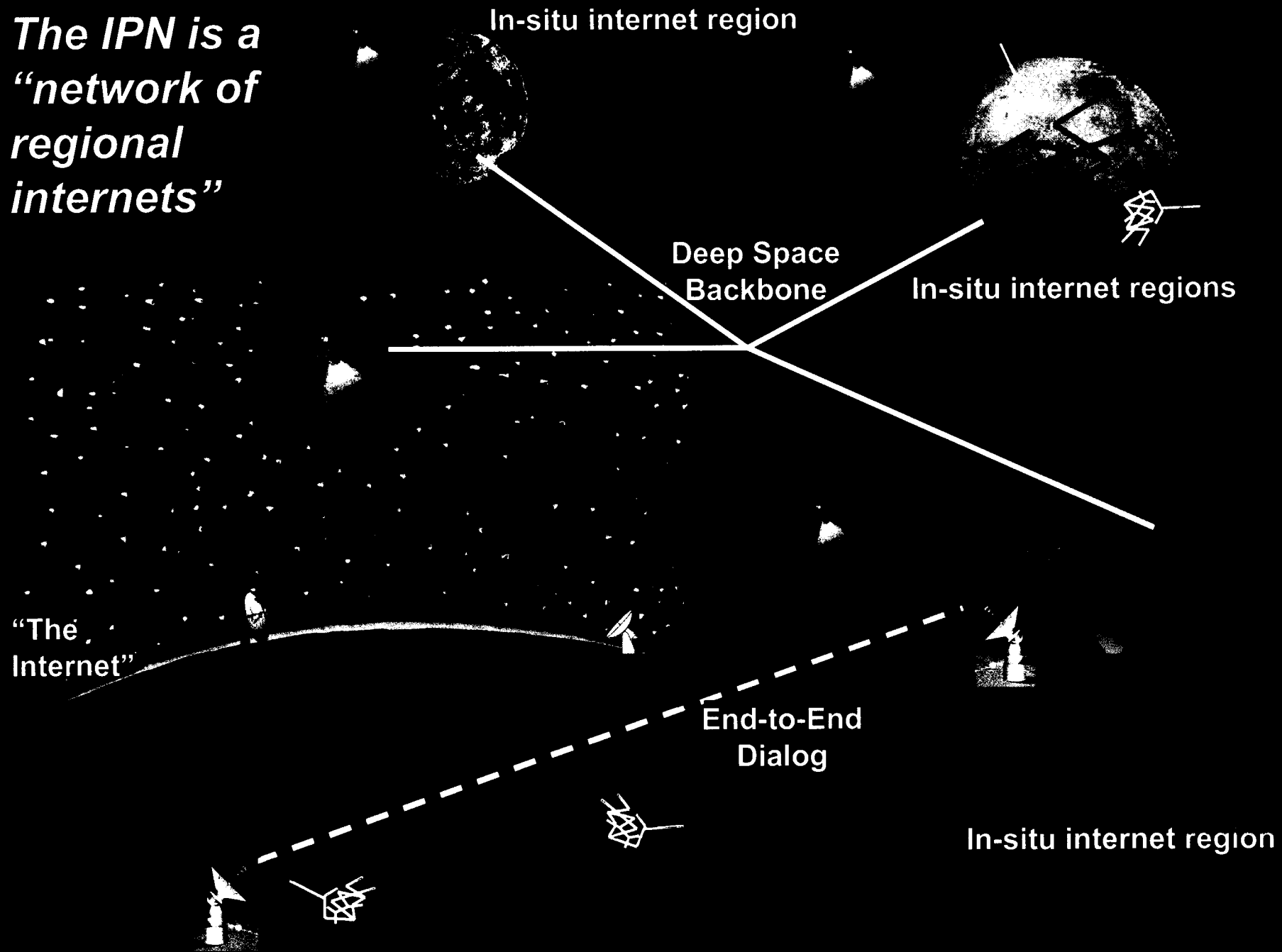
Interplanetary Internet: Internet Life Beyond Planet Earth

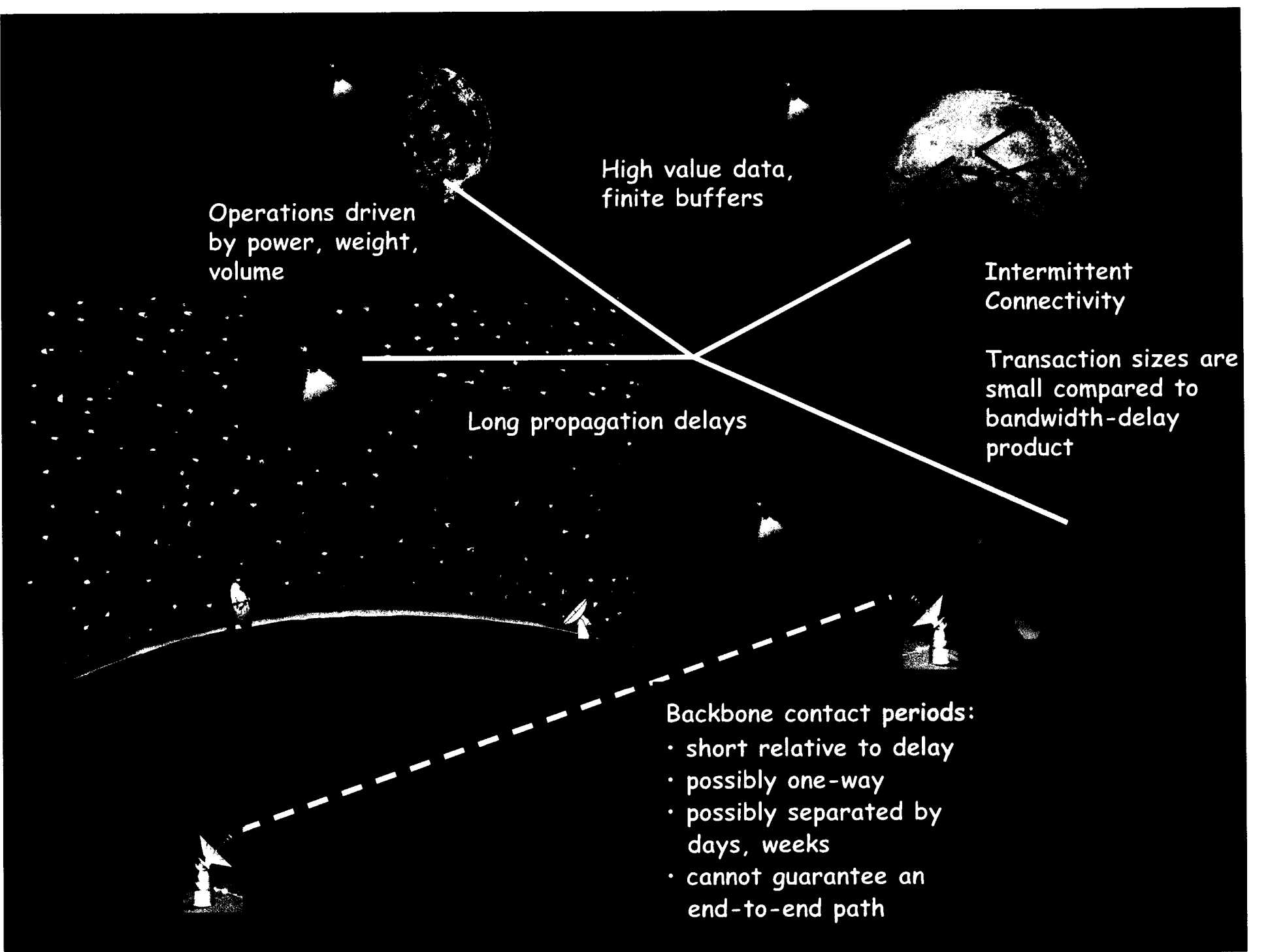
**Vint Cerf
WorldCom Inc. and
JPL Distinguished Visiting Scientist**

Scott Burleigh, JPL
Bob Durst, MITRE Corporation
Kevin Fall, Intel Research
Adrian Hooke, JPL
Keith Scott, MITRE Corporation
Leigh Torgerson, JPL
Howie Weiss, Sparta Inc.

September 2002

*The IPN is a
“network of
regional
internets”*





Operations driven
by power, weight,
volume

High value data,
finite buffers

Intermittent
Connectivity

Transaction sizes are
small compared to
bandwidth-delay
product

Long propagation delays

Backbone contact periods:

- short relative to delay
- possibly one-way
- possibly separated by
days, weeks
- cannot guarantee an
end-to-end path

Sensor Webs

"Delay Tolerant Networking"- reliable communications in highly stressed environments

Delay can be introduced by, e.g.,
Propagation
Intermittent connectivity
Lack of resources (power, buffers)
Simplex or asymmetric channels

Interplanetary Network

HOMELAND SECURITY
PROTECTING THE NATION & ITS PEOPLE

Stressed tactical communications

Sensor Webs

"Delay Tolerant Networking"-
reliable communications in
highly stressed environments

SENSOR WEB FOR
OCEAN MONITORING

Earth Relative View

Earth Relative View
2005/01/06 04:45:29

Beagle

MarB
MarB

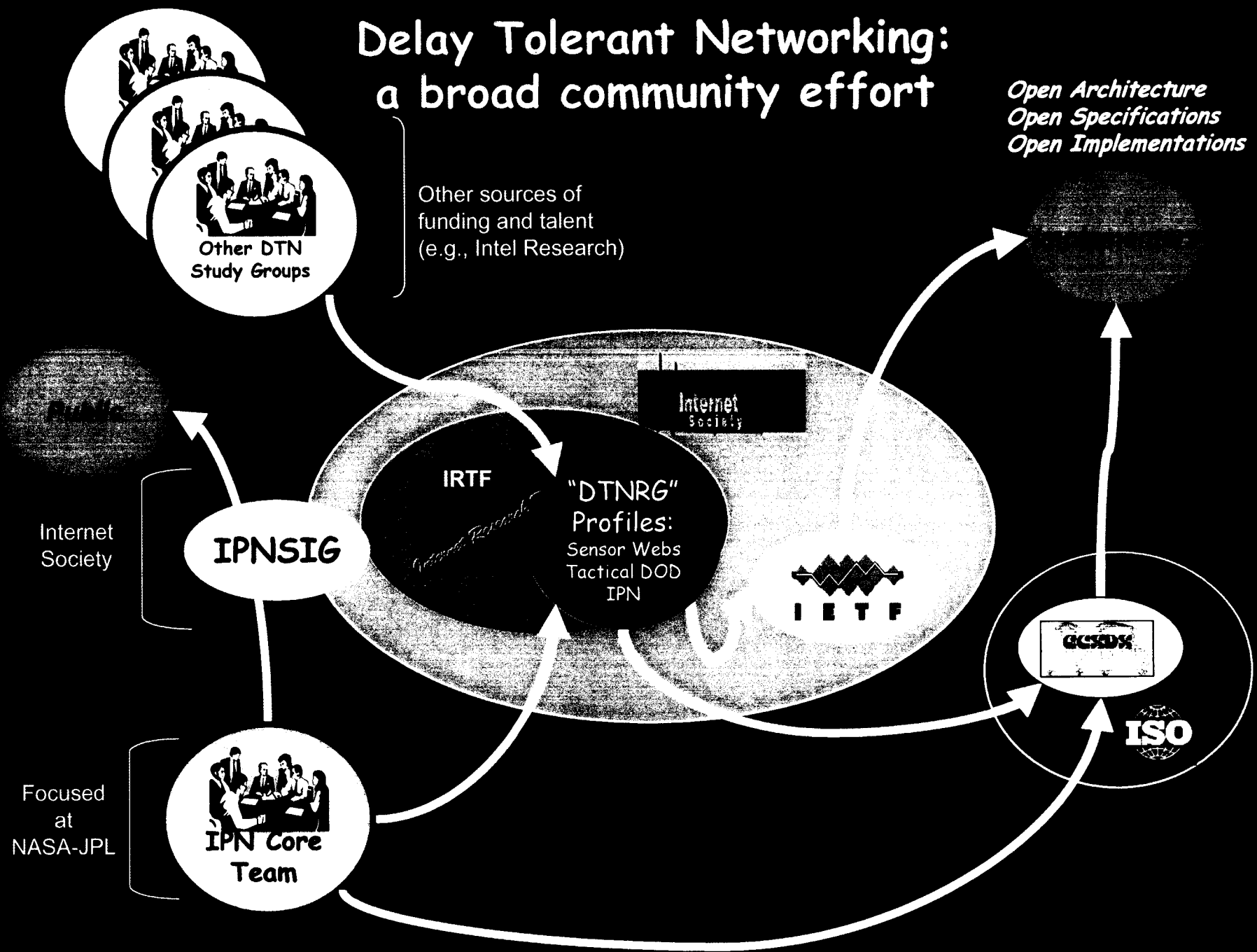
DSS 15

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Stressed tactical communications

Delay Tolerant Networking: a broad community effort



Building the community

Open Architecture
Open Specifications
Open Implementations

IPNSIG

ISO

IPN Core Team

InterPlanetary Internet Special Interest Group - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: <http://www.ipnsig.org/home.htm>

About the IPN SIG

FAQs

Technical Information

Related Links

Press Room

InterPlanetary Internet Project

Internet Society IPN Special Interest Group

Join in the discussion!

Internet Society Members may join the ISOC IPNSIG and participate in the [IPNSIG Discussion list](#) (Non-members may view these posts online, but must [join the ISOC](#) to post to the IPNSIG list.)

Internet Society (ISOC) - Netscape

File Edit View Go Communicator Help

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Bookmarks Location: <http://www.isoc.org/>

Internet Society

All About ISOC
Organization Members

All About the Internet
Global Members

Search/Site Map
Join ISOC

Internet History Education & Training ISOC Logo Standards & Protocols Chapters Press Info Conferences & Events

Conferences and Events

N D S S '03
SYMPOSIUM

Network and Distributed System Security Symposium
* Sponsorship Opportunities *
Patron Sponsor: National Security Agency

5-7 February 2003
San Diego, CA
[Call For Papers](#)

O'REILLY
**OPEN
SOURCE
CONVENTION.**
Reilly Open Source Convention
22-26 July, 2002
San Diego, CA

Headlines

- Internet Society Board Member Maxwell Resigns
- The World Civil Society Forum to be held in Geneva 14-19 July
- Internet Society Announces Election of New Board of Trustees
- Support ISOC's bid to run .ORG!
ISOC is bidding to become the new manager of the .ORG registry. Please read about this exciting opportunity for the Internet Society and [sign a letter of support](#). To date we have received over 500 letters of support from 76 countries.
- Press Release: The Internet Society Seeks to Make .ORGs a Global Home for Non-Commercial Organizations
- Noted Internet Pioneer and Developer Stephen Wolff Receives the Internet Society's Postel Service Award for 2002
- AFNIG Training Programs Help Develop Africa's Internet Infrastructure

[Latest news links on Internet issues]

The Internet Report

Read the Internet Report: [a](#)

Document: Done

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InterPlanNet

InterPlanNet SIG
Discusses issues related to the application of the Internet in outer space.

BABEL
Joint ISOC/Aiis Technologies project on the international Internet.

Document: Done

*DTN User
Communities*

DTN Standardization

- DTNRG
- CCSDS

DTN Core Engineering

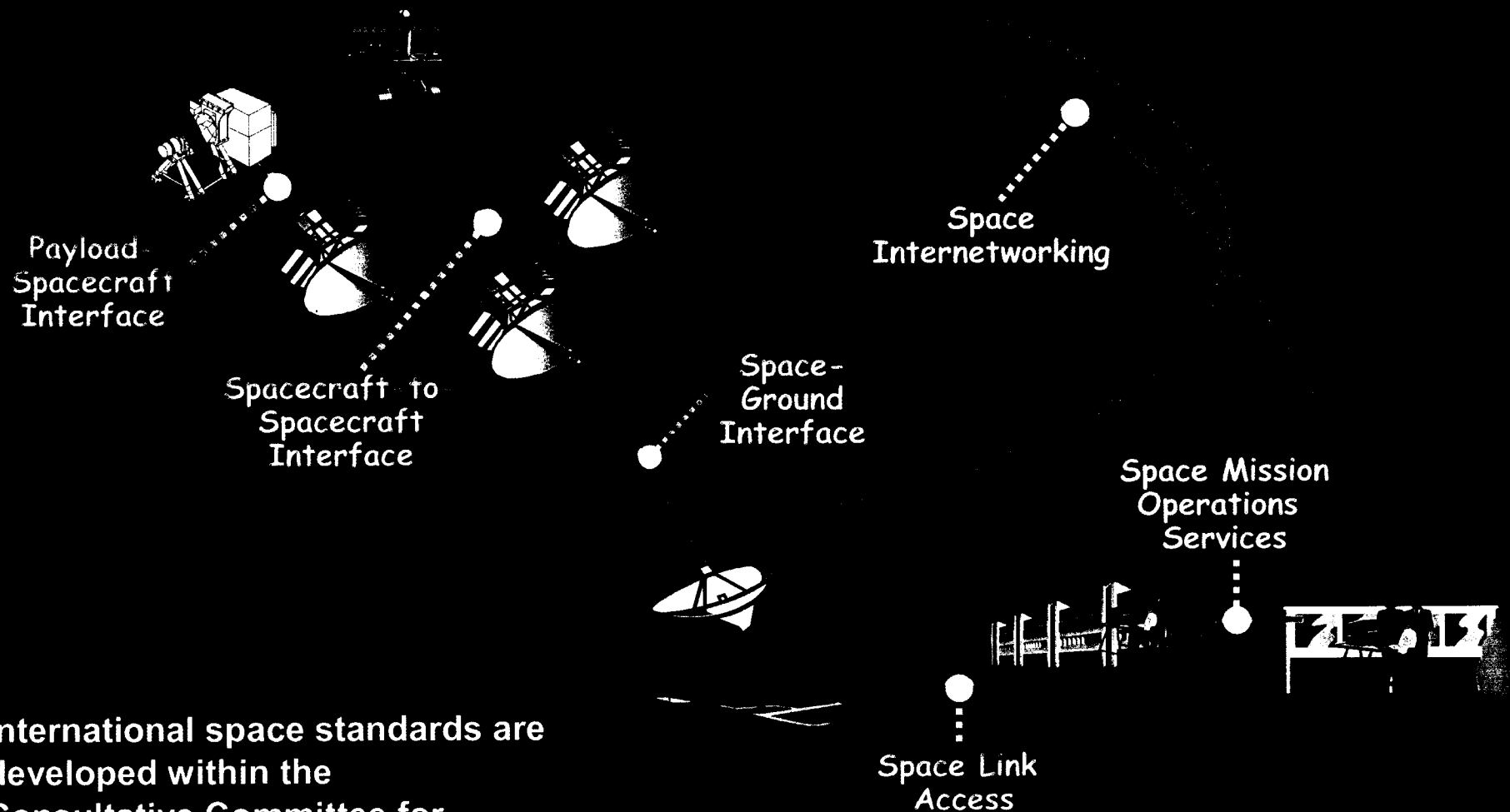
- DTN Architecture
- DTN Design Documents

DTN Open Source Software

- Reference Implementation
- Configuration Control

*DTN Technical
Outreach*

The International Space Community: Standardization Thrusts



International space standards are developed within the Consultative Committee for Space Data Systems (CCSDS)

Current Space/Ground Communications Protocol Stack



Space Applications



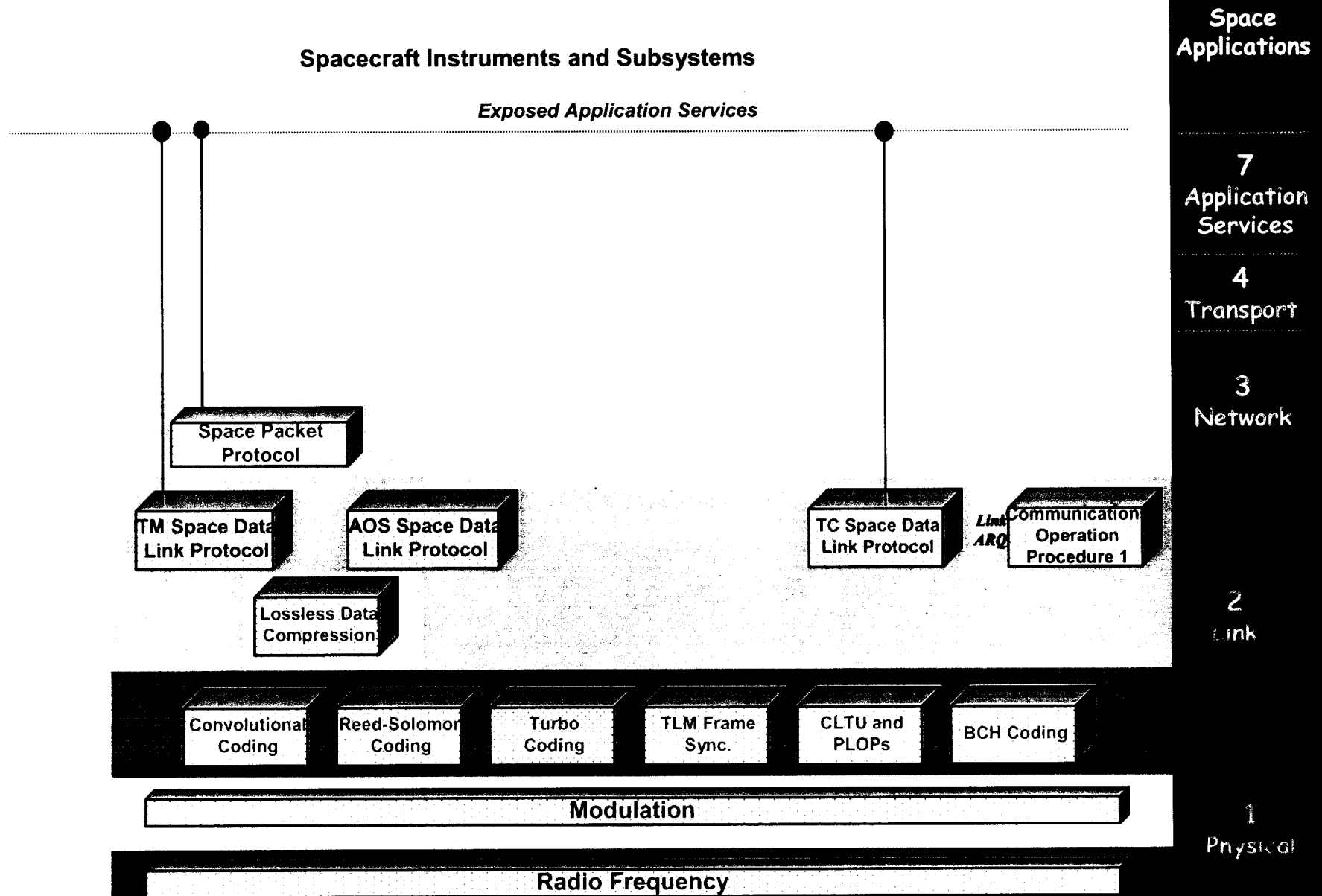
Space Networking

Space Link

Space Channel Coding

Space Wireless Frequency and Modulation

Current Space/Ground Communications Protocol Architecture



CCSDS: The Fleet

Space Domain

- Spacecraft Platforms
- On-Board Systems
- Space Qualified ASICs

IN ~ 20 spacecraft vendors

JAS ~ 25 space component vendors
SIRTF



Consultative Committee for Space Data Systems

221 Missions now using
CCSDS Space Link Protocols
<http://ccsds.gst.com/implementations>

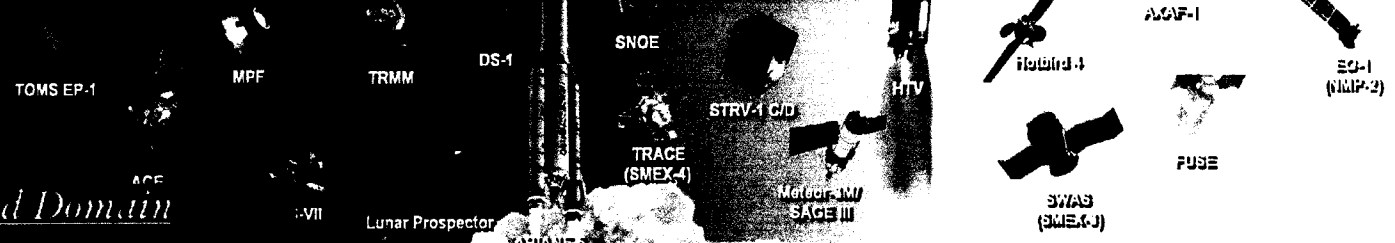
Ground Domain

Commercial Ground Networks
Command & Telemetry Data Processing

2 commercial networks

~ 50 vendors

Extension Forward and Return Services



The Next Few Years

- In the next few years (2002-2005) we will evolve and migrate to add:
 1. A new flavor of CCSDS space link protocol for communicating at short range, e.g., between spacecraft in a constellation or between orbiters and surface assets
 - “Proximity 1” protocol
 2. A more networked set of upper layer standards:
 - CCSDS File Delivery Protocol (CFDP) for disconnected environments
 - Long delays, episodic connectivity
 - Custodial store-and-forward mode
 - Most missions will use this for routine space/ground data hauling
 - Internet suite for richly connected in-situ environments
 - Short delays, stable connectivity
 - Instantaneous end-end dialog
 - Onboard a spacecraft; near-Earth; on and around another planet
 3. Standardized onboard networking

Emerging Space/Ground Communications Protocol Stack



Space Applications

Space File Transfer

Space End-to-End Reliability

Space End-to-End Security

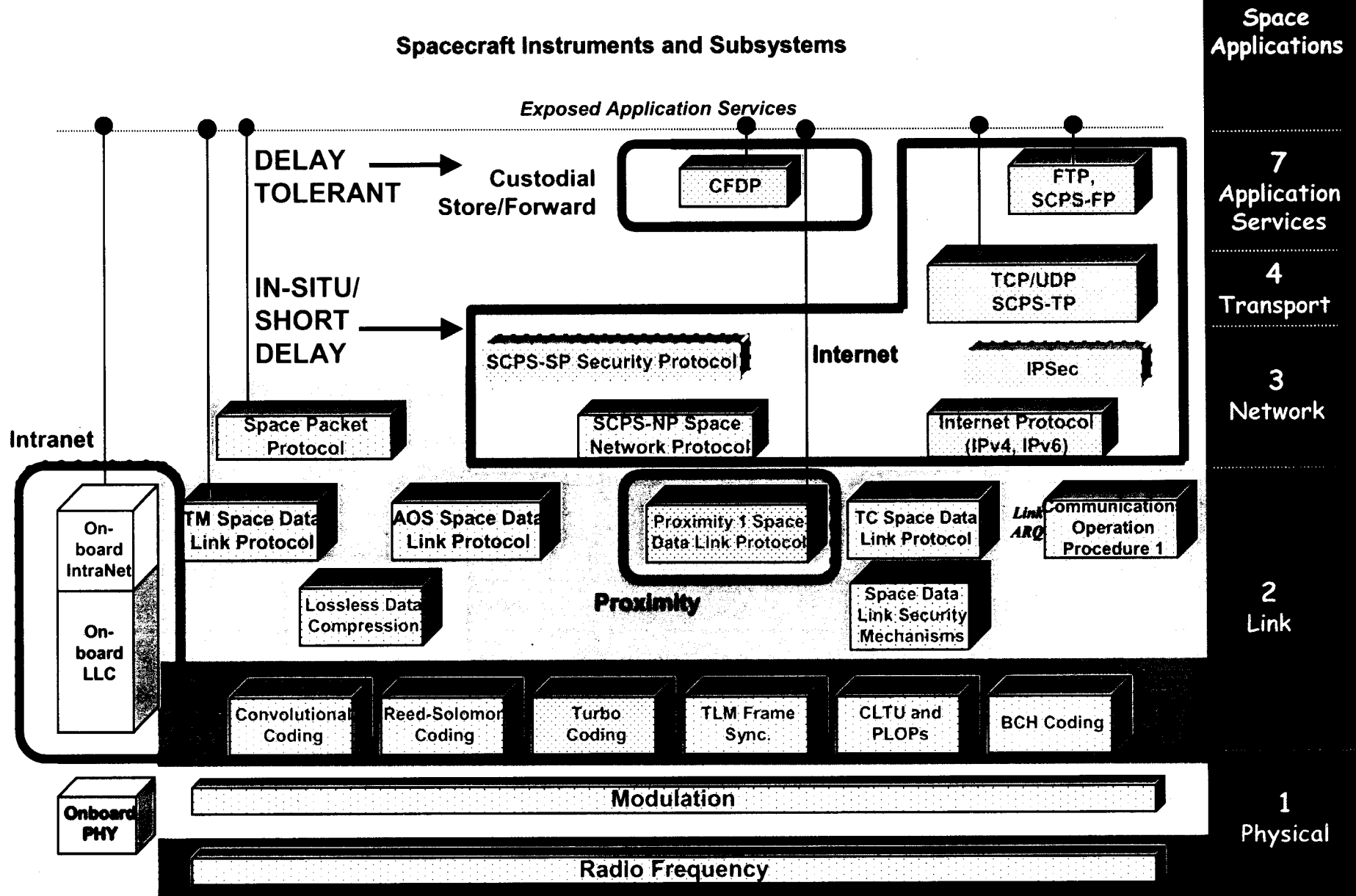
Space Networking

Space Link

Space Channel Coding

Space Wireless Frequency and Modulation

Emerging 2002-2005 Deep Space Communications Protocol Architecture



What is CFDP?

- ❖ The CCSDS File Delivery Protocol is an internationally standardized mechanism to deliver files of space mission data end-to-end through a space network via a series of store-and-forward hops, using custody transfer techniques
- ❖ The current CFDP ("Build 1") provides non-routed, non-custodial delivery through a single hop.

It supports:

- the user application

And consists of:

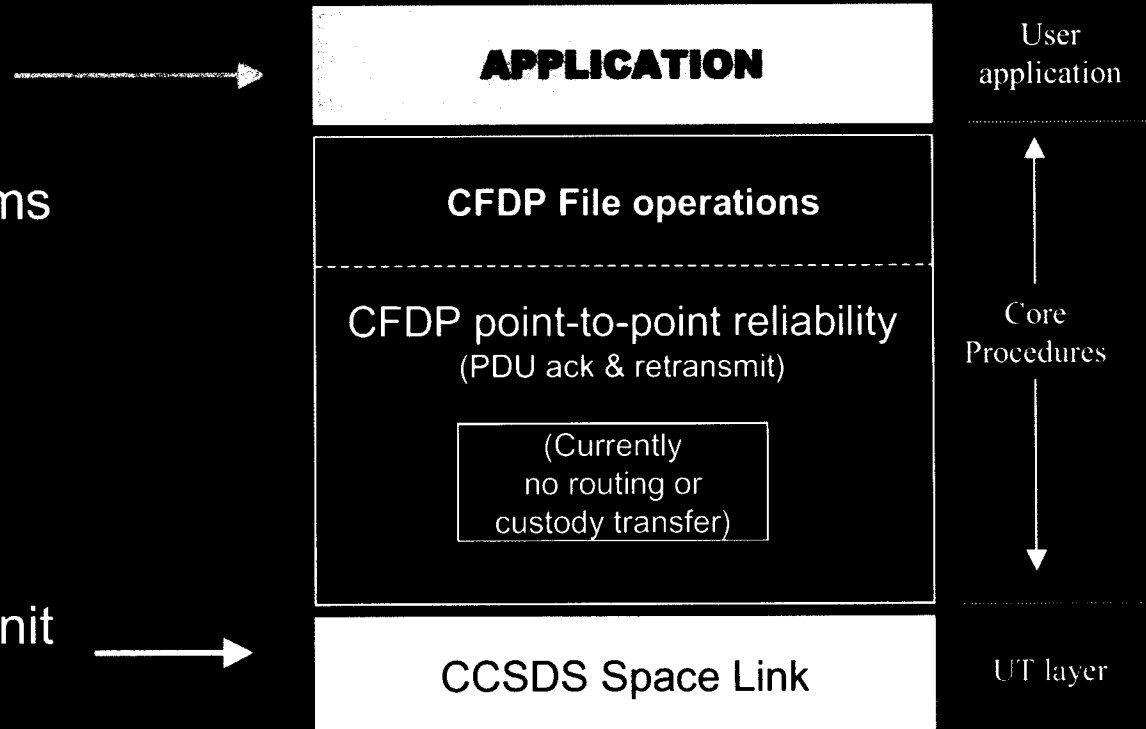
- file handling mechanisms

+

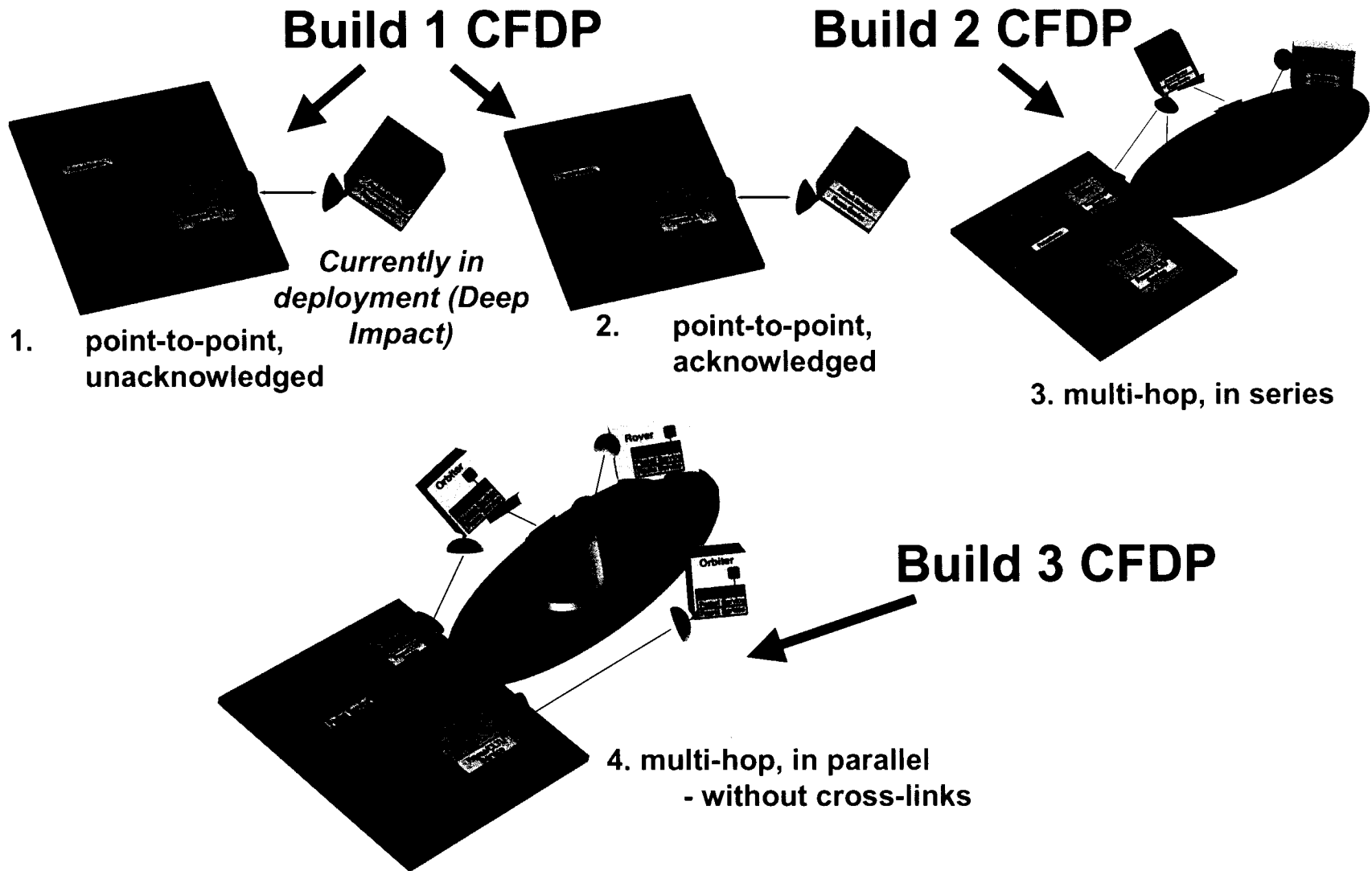
- point-to-point reliability mechanisms

It draws upon:

- underlying space link unit data transfer services



CFDP Operations Scenarios





The 5 year Scenario: fully automated end to end file transfer



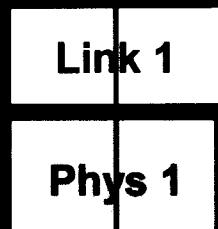
*The IPN is a
“network of
internets”*



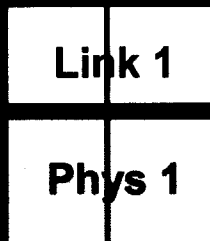
*We need a general way to
communicate in a
disconnected, long-delay
environment*

*So how does all of this
relate to the
Interplanetary Internet?*

The Internet: a Network of Connected Sub-Networks



Subnet 1



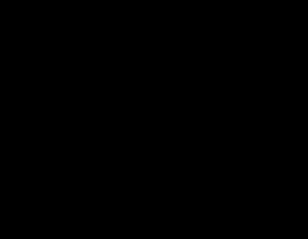
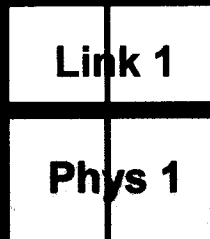
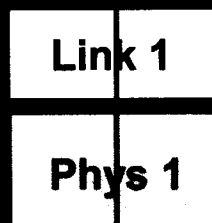
Subnet 2



Subnet 3

Bundles: A Store and Forward Application Overlay

David Clark, MIT, and the Planetary Internet



A "network of internets" spanning dissimilar environments

Emerging Space/Ground Communications Protocol Stack



IPN Applications

File Transfer



BUNDLING

Local Space Reliability

Local Space Security

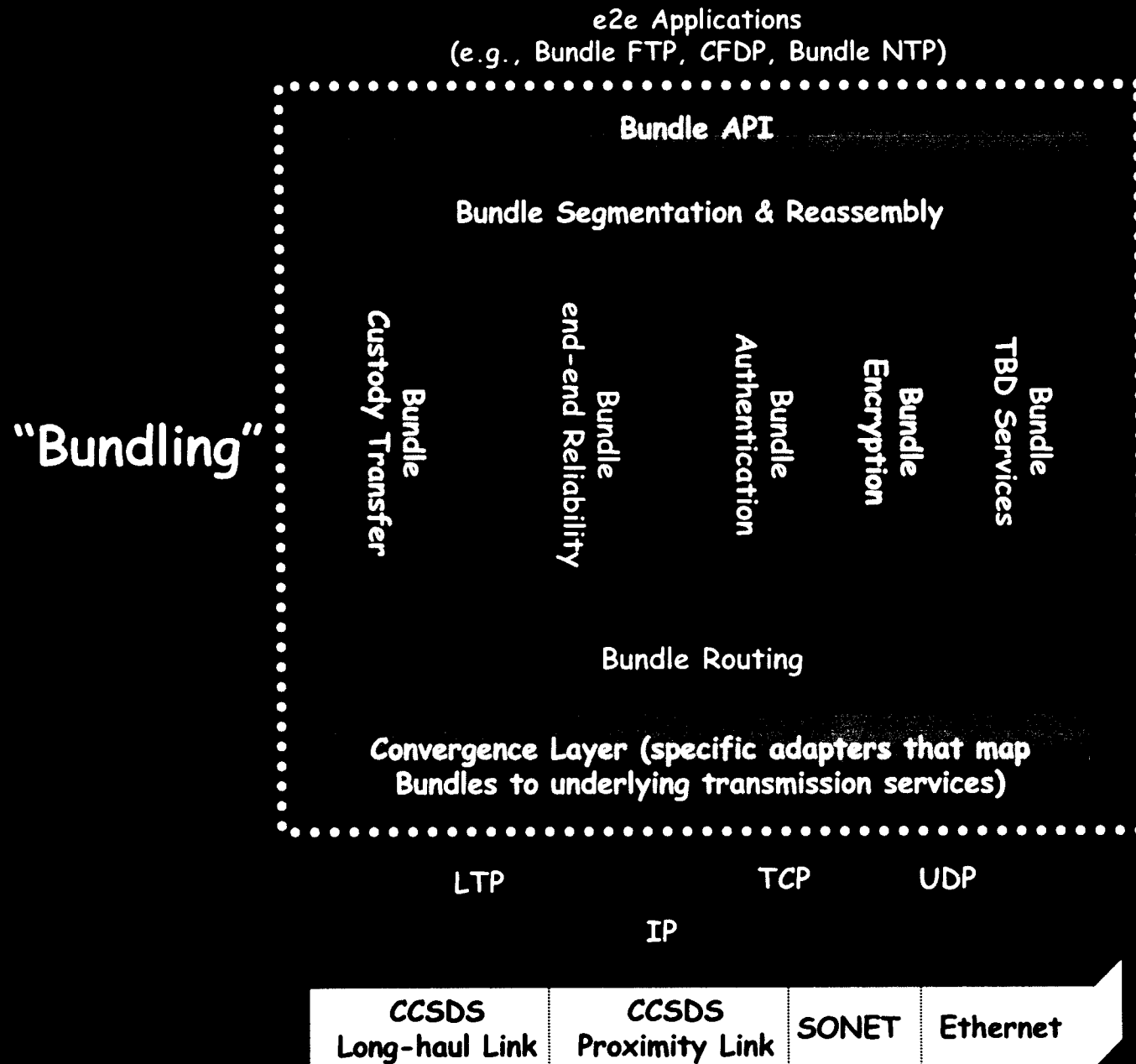
Local Space Networking

Local Space Link

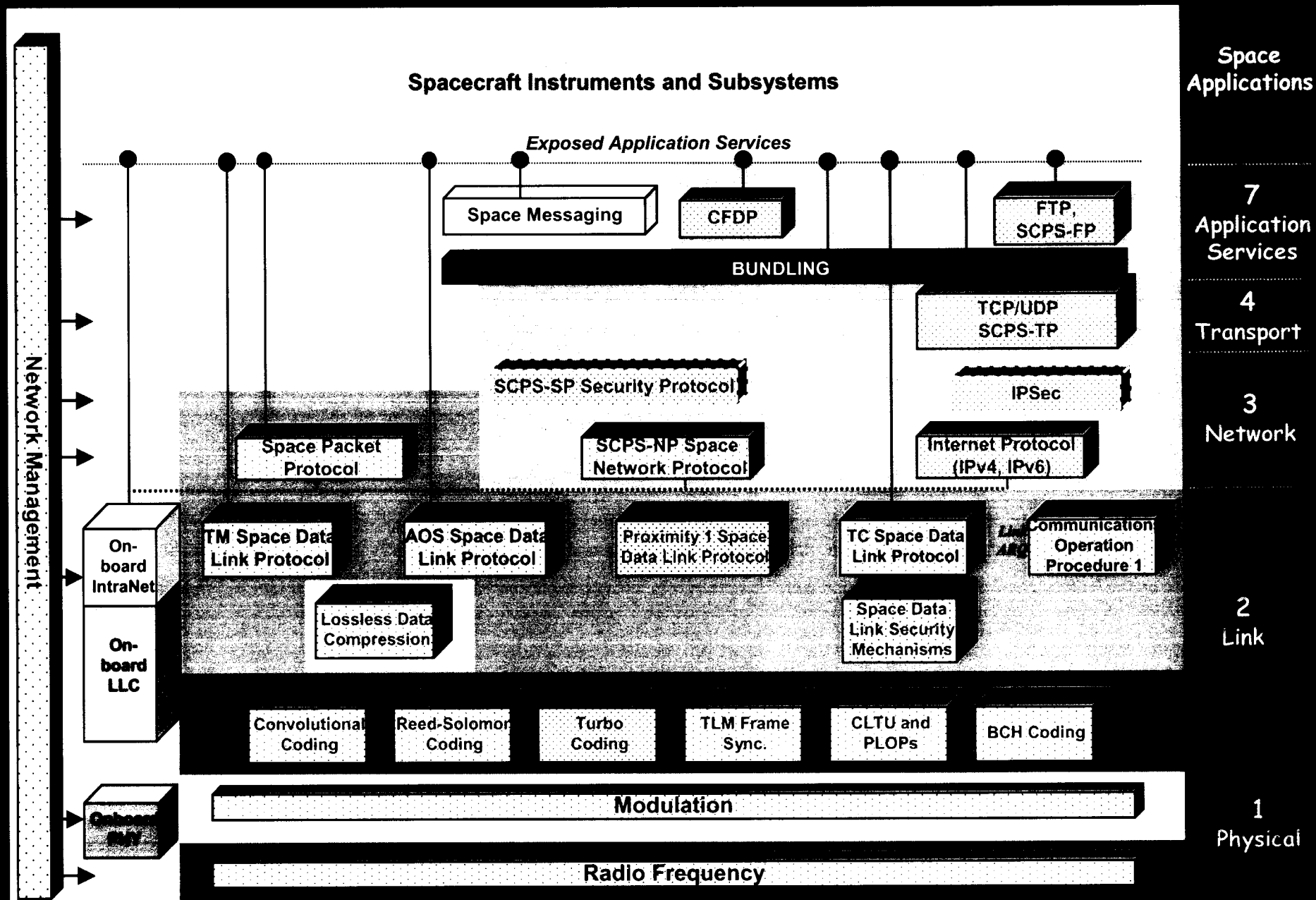
Local Space Channel Coding

Local Space Wireless Frequency and Modulation

Bundle Service Layering



CCSDS Space Communications Protocol Architecture



CFDP

- Store and forward mode
- Transfers files
- Currently point-point:
 - Static Routing
 - Implicit notion of Custody
- Monolithic
- Fairly complex; adding routing + custody transfer will make it more so
- Only of current interest to the 'space' community

Bundling

- Store and forward mode
- Transfers all forms of data
- Inherently networked:
 - Dynamic Routing
 - Full DTN Custody protocol
- Will be internally layered
- Quite complex, but layering will make complexity manageable
- Of wide potential interest to other communities

An IPN Strategy

- Get CFDP into widespread use as a waypoint to Bundling
 - Limit the complexity of the core protocol
- Mobilize other DTN users to develop Bundling as a community effort
 - Broader base of users and applications = faster development and more robustness
- Infuse Bundling to handle needed complexity and simply move a stable CFDP to become an application running over Bundling



the development of the CFDP and its use as a long term was to be fully operational protocol

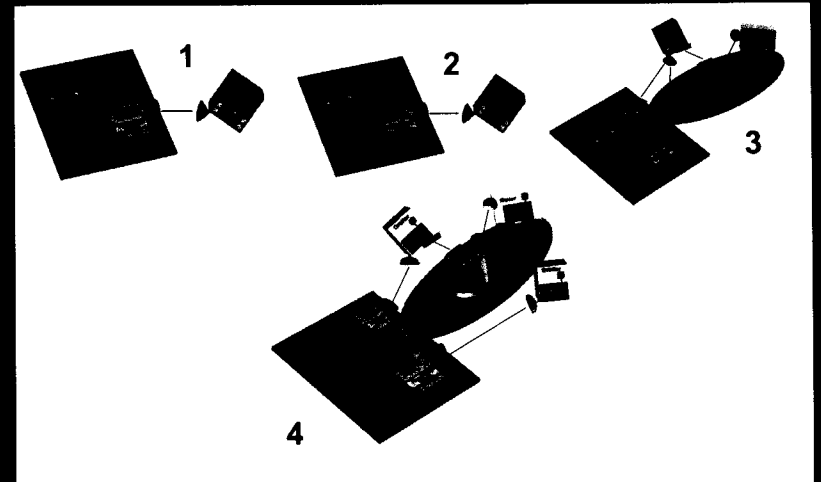


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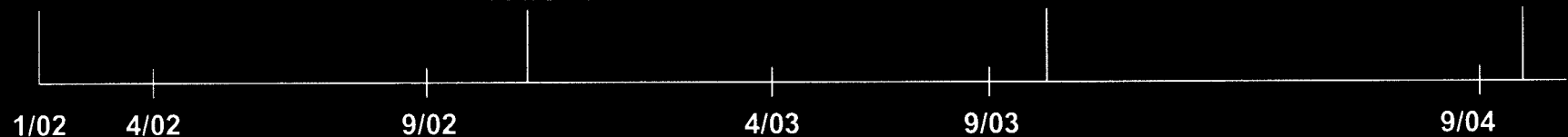


CFDP Core
Procedures

Extended



Build 2/3 Test



*Sensor
Webs*

*Tactical
Military*

*Homeland
Security*

• • •

*Space
Exploration*

*DTN User
Communities*

DTN Standardization

- International Standards Bodies

DTN Core Engineering at JPL

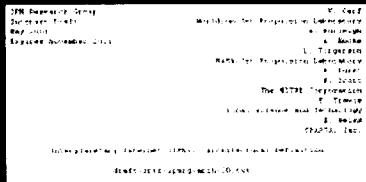
- DTN Architecture
- DTN Design Documents

DTN Open Source

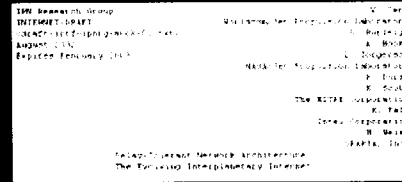
- Reference Software
- Configuration Control

Technical Experimenters

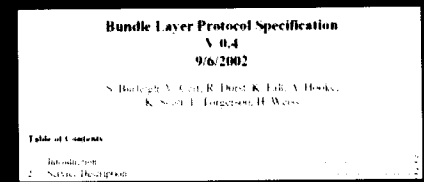
*DTN Technical
Outreach*



IPN Architecture (Internet Draft 1) May 2001

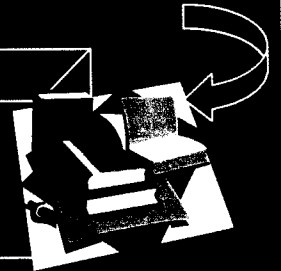


DTN Architecture (Internet Draft 2) August 2002



Bundle Protocol Specification, Draft1 September 2002

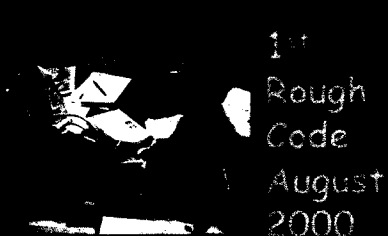
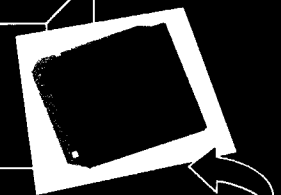
Bundle Specification



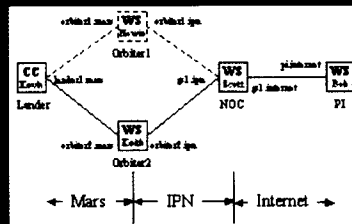
Specifications

Code base

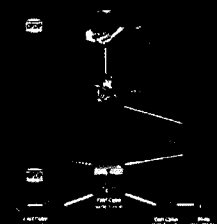
Bundle Prototyping



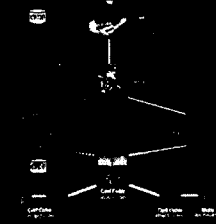
1st
Rough
Code
August
2000



2nd
Proto.
Code
May
2002



3rd
Proto.
Code
July
2002



4th
Proto.
Code
September
2002

CFDP-over-Bundles Experiment.

